Database of Cerebral Artery Geometries including Aneurysms at the Middle Cerebral Artery Bifurcation

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Abstract. This document describes the source, processing steps, and structure of the associated database. The database consists of 50 patient-specific cerebral artery geometries, each including at least an aneurysm at the middle cerebral artery (MCA) bifurcation. It also includes the corresponding patient age and sex, and the MCA aneurysm rupture status. The geometries were selected from the @neurIST database and obtained from segmentation of 3D Rotational Angiography (3DRA) images, and subsequent manual correction. They are high-quality vascular geometries, including at least 12 vessel diameters upstream the aneurysm and 4 vessel diameters downstream the aneurysm.

Keywords: Aneurysm, Aneurysm rupture, Patient-specific, Vascular geometry, Blood flow simulation.

1 Intracranial aneurysms and the @neurIST project

Aneurysms are pathologic dilations of the vessel wall. In particular, the prevalence of intracranial aneurysms (IA) is estimated to be between 2 and 5% [3] and their eventual rupture typically causes subarachnoid haemorrhage, resulting in high rates of morbidity and mortality. However, the low incidence of IA rupture and the significant risk of the available treatments, either by surgery or endovascular, have justified the search for risk predictors in order to determine the best action. Different indicators of their natural evolution have been investigated based on diverse factors, including genetics, clinical conditions, aneurysm size and morphology, and aneurysm haemodynamics.

The European integrated project "Integrated Biomedical Informatics for the Management of Cerebral Aneurysms" (@neurIST; http://www.aneurist.org) [4,2] aimed *to transform the management of cerebral aneurysms by providing new insights, personalized risk assessment, and methods for the design of improved medical devices and treatment protocols.* A key part was the physical characterization of aneurysms in order to find potential risk factors associated with aneurysm rupture, investigating different measures based on morphological, haemodynamic and aneurysm wall structure analyses.

All these factors require to model the personalized geometry of a portion of the vasculature including the aneurysm. In particular, haemodynamic factors require the blood flow simulation in a sufficiently large segment of vessels upstream and downstream the aneurysm location.

2 Extraction of the patient-specific arterial geometries from angiographic images

The 3D Rotational Angiography (3DRA) images of more than 300 patients having at least one IA were collected and processed as part of the project @neurIST. First the 3DRA images were automatically segmented with the geodesic active region segmentation method presented and evaluated in [1]. This results in a model of vascular surface geometry represented by a triangular mesh. Then, the resulting model were manually refined to remove some of the artefacts producing unrealistic anatomies. Finally, the vascular region of interest was isolated by clipping the desired inlets and outlets with planes perpendicular to the vessel centreline.

The resulting high-quality patient-specific vascular geometry includes at least 12 vessel diameters upstream the aneurysm and 4 vessel diameters downstream the aneurysm.

3 Identification of the aneurysm neck surface

The aneurysm neck was manually delineated on the surface model. This result in a non-planar closed contour identifying the boundary between healthy vessels and aneurysm. From this contour a surface is generated smoothly propagating the contour towards its barycentre.

4 Selection of 50 cases with aneurisms located at middle cerebral artery bifurcation

The location with higher aneurysmal prevalence is the middle cerebral artery (MCA) bifurcation. A set of 50 patient-specific geometries including an aneurysm in the MCA bifurcation were selected from the @neurIST database. This database consists of these 50 cases, including the vascular geometry, the aneurysm neck surface, the corresponding patient age and sex, and the MCA aneurysm rupture status.

Note that, as is common in most aneurysmal studies, the rupture status is the one at the time of the image acquisition (retrospective). No information on subsequent rupture events is available.

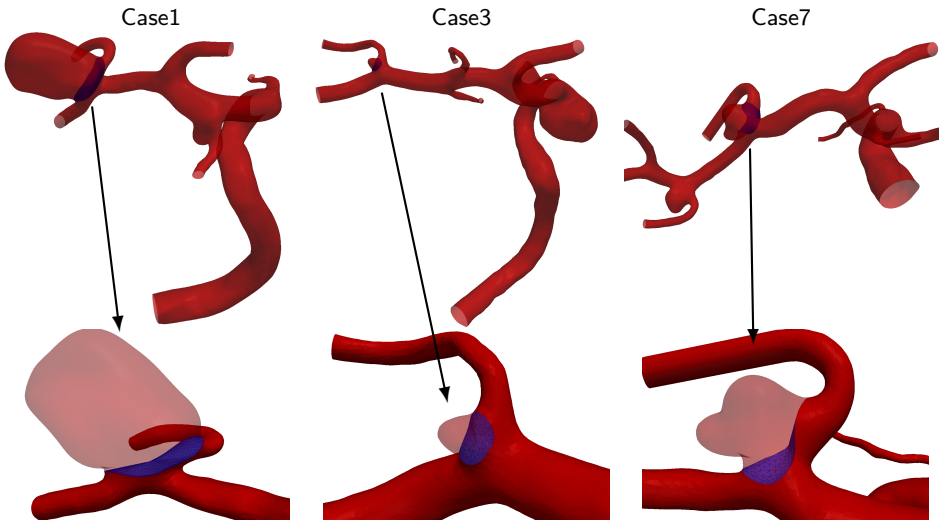

Fig. 1. Three examples of the vascular geometries and neck surfaces included in the database. Observe that they can include other aneurysms at other locations. Only the aneurysm at the MCA bifurcation includes the identification of the aneurysm neck.

5 Database structure

The database includes the following files and folders:

`MCADatabaseDescription.pdf` This same document describing the database.

`CasesMCAWithRuputureAgeAndSex.csv` A table in coma-separated-value format providing the sex and age of each patient, and rupture status of the MCA aneurysm.

`VesselWallSurfaces` A folder including the files **`Case1.vtk ... Cases50.vtk`**. Each file is a model of the vessel geometry surface as a triangular mesh. It is saved in vtkPolyData format.

`NeckSurfaces` A folder including the files **`Case1.vtk ... Cases50.vtk`**. Each file represents the surface of the corresponding aneurysm neck, as a triangular mesh in vtkPolyData format.

The vtkPolyData format is part of the open-source library *Visualization Toolkit* (http://www.vtk.org/), which constitutes a *de facto* standard. The vtkPolyData files can be open and visualized, for instance, with the open-source softwares *ParaView* (http://www.paraview.org/) or *GIMIAS* (http://www.gimias.org/).

6 Database licence

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For any doubt, please, contact the corresponding authors.

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References

1. Bogunović, H., Pozo, J.M., Villa-Uriol, M.C., Majoie, C.B.L.M., van den Berg, R., Gratama van Andel, H.A.F., Macho, J.M., Blasco, J., San Román, L., Frangi, A.F.: Automated segmentation of cerebral vasculature with aneurysms in 3DRA and TOF-MRA using geodesic active regions: An evaluation study. Medical Physics 38, 210 (2011)
2. Iavindrasana, J., Lo, I.L., Müller, H., Periz, I., Summers, P., Wright, J., Friedrich, C.M., Dach, H., Gattermayer, T., Engelbrecht, G., Benkner, S., Hofmann-Apitius, M., Dunlop, R., Arbona, A., Rajasekaran, H., Fingberg, J., Chiarini, A., Moore, B., Bijlenga, P., Hose, R.D., Frangi, A.F.: The @neurIST project. Stud. Health Technol. Inform. 138, 161–164 (2008)
3. Rinkel, G.J.E., Djibuti, M., Algra, A., Van Gijn, J.: Prevalence and risk of rupture of intracranial aneurysms a systematic review. Stroke 29(1), 251–256 (1998)
4. Villa-Uriol, M.C., Berti, G., Hose, D.R., Marzo, A., Chiarini, A., Penrose, J., Pozo, J.M., Schmidt, J.G., Singh, P., Lycett, R., Larrabide, I., Frangi, A.F.: @neurist complex information processing toolchain for the integrated management of cerebral aneurysms. Interface Focus 1(3), 308–319 (2011)